SLS-2 Final Report (NAG2-500) Experiment 141

REGULATION OF BLOOD VOLUME DURING SPACEFLIGHT

Principal Investigator:

Clarence P. Alfrey, M.D.

Baylor College of Medicine
Department of Medicine
The Methodist Hospital
6565 Fannin, Mail Station 902 Main Bldg.
Houston, Texas 77030
Telephone: (713) 790-2157
Fascimile: (713) 790-0828

Co-Investigators:

Mark M. Udden

Theda Driscoll

Mark Pickett

Baylor College of Medicine
Houston, Texas

SUMMARY ABSTRACT

The effects of spaceflight on erythropoiesis and blood volume in the rat were studied during the 14-day NASA Spacelab Life Sciences 2 (SLS-2) Shuttle mission. Measurements included red blood cell mass (RBCM), plasma volume (PV), iron utilization and iron utilization in response to an injection of erythropoietin. Red blood cell (RBC) survival, splenic sequestration and erythrocyte morphology were also evaluated. At landing, the RBCM adjusted for body weight was significantly lower in the flight animals than in the ground controls. While the PV was also decreased, the change was not statistically significant. Incorporation of iron into circulating RBCs was normal when measured after five days of spaceflight and the rat responded normally to the single in-flight injection of erythropoietin. No change in RBC morphology could be attributed to spaceflight. A normal survival was found for the RBC population that was represented by ^{51}Cr labeled RBCs. These results demonstrate that rats, like humans, return from spaceflight with a decreased RBCM and total blood volume.

OBJECTIVES

Human adaptation to microgravity during spaceflight is accompanied by a consistent loss of red blood cell mass (RBCM), plasma volume (PV) and total blood volume (4, 8, 16). The reduction in blood volume after exposure to microgravity has been attributed to the loss of gravity-dependent spaces below the level of the heart that are ordinarily present in an upright individual (15). The study of rats exposed to microgravity was undertaken to determine whether similar volume changes occurred in these animals.

INTRODUCTION

Reassessment of blood volume changes in rats subjected to spaceflight is complicated by the continued growth of the animal and the accompanying increase in RBCM and PV that occurs during the mission. Numerous studies of rats subjected to spaceflight have examined peripheral blood and bone marrow upon landing. The findings have been reported to indicate decreased erythropoiesis or no change (3, 5, 6, 7, 18). When our laboratory measured RBCM and PV directly using radionuclide dilution methods on the 9-day SLS-1 mission, a clearer picture emerged (17). Both the RBCM and PV of the flight animals were significantly decreased at the end of the mission compared to controls when adjusted for body weight (ml per 100g). ^{59}Fe incorporation into RBCs indicated there was decreased erythropoiesis in the flight animals throughout the 8-day post-flight observation period (17).

Here we report the results of a study of rats flown on the 14-day NASA Spacelab Life Sciences 2 Shuttle mission (SLS-2). In addition to pre- and post-flight determinations of RBCM and PV, this study included the first in-flight measurements of PV and assessment of erythropoiesis. These technically difficult experimental manipulations of rats, obtained under conditions of microgravity by the SLS-2 crew members, enabled us to address three important questions raised by earlier work: (1) Does plasma volume decrease significantly in the rat during spaceflight as it does in humans?; (2) Is there evidence for decreased erythropoiesis during spaceflight and (3) Does the bone marrow of the space-adapted rat have a normal response to exogenous erythropoietin, the principal regulating hormone of erythropoiesis?

MATERIALS AND METHODS

Animals. Male, specific pathogen-free, Sprague-Dawley rats supplied by Taconic Laboratories (Indianapolis, IN) were flown on the shuttle Columbia during the SLS-2 mission (also designated STS-58). The experimental design was approved by the animal care and use committees of Baylor College of Medicine and the NASA Ames Research Center. The animals were handled in a humane manner under the supervision of a veterinarian and in accordance with national and international standards. A veterinarian also participated as a crew member during the 14-day flight.

The animals were housed in Florida at the Kennedy Space Center (KSC) vivarium facility for four weeks prior to launch. Fifteen animals were selected for spaceflight and 15 were selected to be ground controls. During the flight, the animals were housed in the Research Animal Holding Facility (RAHF). The RAHF provided automatic temperature and humidity control, a waste management system and food and water upon demand. Due to an in-flight adjustment of temperature control, the ambient temperature during the flight was 28 °C. The 15 ground control animals were maintained at a similar temperature in simulated RAHF cages. One day after launch, the controls were transferred by airplane to the shuttle landing site and housed at the Dryden Payload Receiving Facility (PRF), Edwards Air Force Base, California. Animals were housed in individual cages and were on an automatic 12/12 lighting cycle throughout the study.

Seven days prior to launch, both the flight and control animals underwent determinations of PV and RBCM by radionuclide dilution methods. On flight day six (FD6), one group of five animals received injections of ^{125}I-labeled albumin and ^{59}Fe-ferrous citrate. Samples were taken ten minutes later for PV determination and 24 hours later for determination of ^{59}Fe incorporation into RBCs. On FD9, the remaining 10 animals received an injection of ^{59}Fe. Half of these animals were given a 200U bolus of recombinant human erythropoietin (rhEPO), (Epogen, Amgen, Thousand Oaks, CA). The other half received a saline injection of the same volume. Procedures were performed concurrently on flight and ground control animals. On the day of landing, the following determinations were made for all flight and ground control animals: PV, RBCM, ^{51}Cr spleen to liver ratio, ^{51}Cr RBC survival, and percentage of ^{59}Fe incorporated into RBCs. The post-flight samples for these determinations were obtained 3 to 6 hours after landing. Animals were weighed daily during the pre-flight period, twice during the flight and upon return to earth.

Red blood cell mass and plasma volume determinations. Previously described radionuclide

dilution methods were used to determine the RBCM and PV (13). Briefly, for each pre- and post-flight PV determination, 1 μCi of ^{125}I-labeled albumin in a volume of 0.1 ml was injected. ^{51}Cr-labeled RBCs were used for the RBCM determinations. Blood obtained by cardiocentesis from one or two donor rats was incubated with ^{51}Cr-sodium chromate and the RBCs were then washed and diluted with saline. The final concentration of ^{51}Cr was 5 μCi per 0.2 ml and the hematocrit was 55%. The radiolabels were injected at the same time in a volume of 0.3 ml and a blood sample was obtained 10 minute after the injection. For the in-flight PV determinations, 1 μCi of ^{125}I-labeled albumin in a volume of 0.4 ml was injected. Pediatric catheters were placed in the tail vein to obtain a background blood sample and make an injection (14). The post-injection blood sample was obtained with a second venipuncture in a contra-lateral tail vein. The volume of blood required was less than 0.3 ml for the background, the 10 minute sample and an aliquot provided to other investigators participating in this mission.

^{59}Fe incorporation into circulating red blood cells. Three μCi of ^{59}Fe-ferrous citrate in a volume of 0.4 ml was injected intravenously. Blood samples were obtained 24 hours after injection to determine the early incorporation rate and on landing day to determine the maximum amount incorporated. This maximum value was determined at 9 days after the FD6 injection and at 6 days after the FD9 injection. The values are expressed as the percentage of ^{59}Fe in total circulating RBCs, *i.e.*, net counts per minute (NCPM) per ml of RBCs times RBCM divided by NCPM ^{59}Fe injected. The RBCM determined on landing day was used in the maximum value calculation and the body mass was used to estimate RBCM for calculation of the 24 hour value. A linear change between pre-flight and post-flight values of RBCM per 100 grams body weight was assumed for the estimates of the in-flight RBCM values (1, 9).

In addition to the ^{59}Fe injection on FD9, half of the animals were scheduled to be injected IV with 200 units rhEPO and the other half with an equal volume of saline. On FD9, the in-flight injections proved to be technically difficult in two animals. Venous catheter placement was not achieved in one and a sub optimal injection was noted in the crew experiment log for a second animal. Subsequent measurement of iron incorporation confirmed the minimal administration of ^{59}Fe to that animal. Both of these animals were in the saline injection group, leaving this group with three animals instead of the five that was originally planned.

^{51}Cr-labeled donor RBC survival and spleen sequestration. Because of the growth of the animals and the concomitant increase in RBCM, the estimate of RBC survival was based upon total

circulating ^{51}Cr, *i.e.*, NCPM per ml RBC times RBCM. This value was determined twice, once at the start of the study when the ^{51}Cr-labeled RBCs were injected 7 days pre-flight and again on landing day when a second RBCM was determined. On the basis of these two data points, the RBC survival $T_{1/2}$ was estimated in days.

On landing day, the liver and spleen were removed at dissection. The total organ weights were obtained, a tissue sample from each organ was weighed and the ^{51}Cr activity of the sample was determined. The total organ ^{51}Cr content was calculated (NCPM per gram times total organ weight in grams). The ratio of spleen to liver ^{51}Cr radioactivity was calculated.

RBC morphology. A drop of blood from the tail vein venipuncture was added to 1.0 ml of 0.5% glutaraldehyde in phosphate buffered normal saline containing 1.13 mM calcium and 1.0 mM magnesium chloride buffer. Samples were obtained pre-, in- and post-flight. Later these were mounted wet on glass slides under cover slips and examined under light microscopy at 1000x magnification. One thousand cells were counted to determine the number of normal RBCs (discocytes) and spiculated cells (echinocytes).

In-flight experiment equipment. Procedures were carried out within the General Purpose Work Station (GPWS), a glove box designed for the Spacelab. Experimental supplies for blood sampling and injections were contained in special in-flight kits designed by the NASA Ames Research Center for use in microgravity. The Small Mass Measurement Instrument (SMMI) was used to determine rodent body mass.

Statistical methods. Data are expressed as means ± SE for the ground control and the flight animals. Statistical analysis included the Repeated Measurements ANOVA, One Factor ANOVA and Bonferroni - Dunn test. A nonparametric statistical test, the Mann-Whitney U was applied when the number of observations per group was less than 5. Statistical significance was set at the $p \leq 0.05$ level.

RESULTS AND DISCUSSION

Shown in Figure 1 are the growth curves for the flight and ground control animals. Below 150 grams the two groups had identical growth rates but for the remainder of the pre-flight period the control group gained weight at a slightly faster rate while during the mission the flight animals

grew at a faster rate. The difference was not statistically significant during the pre-flight period but was during flight.

Shown in Figure 2 are the pre- and post-flight RBCM and PV results expressed as absolute volume (A, B) and as volume normalized for body weight (C, D). Rats injected with rhEPO were not included in the calculation of these means (n=10). The absolute volume of RBCM and PV increased due to the growth of the animals during the 21 days between measurements. The absolute RBCM measured in the flight animals on landing day was smaller than the control value. When RBCM was normalized for weight, there was a significant difference between the flight animals and the ground controls. No significant difference was found between the control and flight animals when the PV was expressed as an absolute volume or when normalized for body weight. Statistical analysis of the weight normalized total blood volume, *i.e.*, RBCM plus PV, showed that on the day of landing, the flight animal mean (6.25 $\pm$ .09 ml /100 g) was significantly less than the control mean (6.69 $\pm$ .08 ml /100 g).

Shown in Figure 3 are the mean PVs normalized for weight for the 5 flight and 5 ground control animals that had additional PV determinations on FD6 and 8 days post-flight. The flight group mean was smaller than the control mean at each determination but at no time was the difference significant.

^{59}Fe RBC incorporation values after the FD6 injection are shown in Figure 4. Mean values are shown for 24 hours and 9 days post-injection (landing day). There was no significant difference between the flight animals and the ground control animals and the values were within normal limits. Following the FD9 injection, ^{59}Fe incorporation values were within normal limits except for the 24 hour mean of the ground control animals injected with saline (Figure 5). This mean was statistically less than the other 24 hour values of this study and our normal values when identical methods were used to determine RBC incorporation of iron during ground based flight experiment verification tests. In one ground based study the 24 hour mean $\pm$ SE was 37 $\pm$ 1% for 5 animals injected with saline and 44 $\pm$ 4 % for 5 animals injected with rhEPO. As indicated in Figure 5, the 24 hour mean value for flight animals injected with rhEPO was significantly greater than the mean for flight animals injected with saline. The mean values on the sixth day post-injection (landing day) were normal and there was no difference between groups.

The survival of RBCs labeled with ^{51}Cr 7 days prior to launch was not affected by spaceflight.

The mean $\pm$ SE of the $T_{1/2}$ was 19.6 $\pm$ 1.3 days for the ground controls and 20.3 $\pm$ 1.0 days for the flight animals. There was no increased splenic sequestration of these cells. The mean $\pm$ SE of the ^{51}Cr spleen to liver ratio was 1.5 $\pm$ 0.2 for the controls and 1.6 $\pm$ 0.2 for the flight animals.

No change relative to spaceflight was found in the number of echinocytes or other non-discocytes (Data not shown). There was considerable daily variability in the proportions of these cells in both the flight and ground control animals.

At the end of this 14-day mission, RBCM normalized for body weight was significantly decreased in the flight animals compared to ground controls and these results confirm our findings for the 14 rats that flew on the 9-day SLS-1 mission (17). While PV normalized for the weight of the animal showed no statistically significant flight-related difference, the changes were in the same direction as the significantly decreased PV that was found for the rats that flew on the SLS-1 mission (17). The absence of a significant change in PV after 6 days of spaceflight indicates that the decrease in total blood volume of the rat is not accompanied by the same marked reduction in PV that is seen when humans adapt to microgravity (16).

Erythropoiesis was evaluated by measuring the incorporation of radiolabeled iron into circulating RBCs during exposure to microgravity. In-flight ^{59}Fe studies on FD6 and FD9 indicate that utilization of iron by the bone marrow was at the same level as in ground based studies of normal rats. A 24-hour RBC incorporation rate of about 40% and a maximum plateau between 65 and 75% by three days post-injection have been reported (2, 9, 12). We have no explanation for the low 24-hour mean value of 29% that was found for the ground control group after the FD9 injection. An increased 24-hour incorporation rate in response to the injection of rhEPO demonstrates that erythropoiesis is stimulated normally by this hormone under conditions of microgravity. These results are consistent with the presence of a marrow that is actively using iron and releasing ^{59}Fe-labeled RBCs into the circulation at a normal rate.

This was the first time that erythropoiesis in the rat has been studied in-flight. The bone marrow of rats flown aboard Cosmos biosatellite missions of 5 to 22 days duration has been studied post-flight and evidence of decreased erythropoiesis has been reported (3, 5, 18). When bone marrow cells were cultured *in vitro* with EPO after the SL-3 mission, there were increases in the number of BFU-e and CFU-e colonies in flight animals (6) while results from SLS-1 showed a decrease in the number of these colonies (17). Also, iron utilization by RBCs was decreased throughout an 8-

day post-flight period (17). These reported post-flight changes may have been affected by the stress associated with re-entry and landing since studies reported here indicate a normal marrow from the 6th day of spaceflight to the end of the mission.

A RBC precursor, ^{14}C-glycine, was used to study rats flown on two 19-day Cosmos biosatellite missions. The findings indicted accelerated hemolysis during some portion of the mission and a shortened RBC life-span was reported (10, 11). We found no change in RBC survival or splenic sequestration of ^{51}Cr-labeled RBCs during this mission or the SLS-1 mission (17). The spleen to liver ratio reflects the cumulative deposition of all ^{51}Cr-labeled RBCs that were removed from circulation from the pre-flight injection day to landing day. If the survival of ^{51}Cr-labeled RBCs had been shortened by exposure to microgravity, then the spleen to liver ratio would have been larger in the flight animals. RBCs that were produced after the injection of the labeled RBCs were not represented in our ^{51}Cr survival measurements. The survival of this small sub-population of young cells can not be ascertained from our studies.

CONCLUSIONS

Our results demonstrate that rats, like humans, return from spaceflight with a RBCM and total blood volume that is less than it would have been if they had remained on earth. The absence of a significant change in PV during the mission indicates that the regulation of total blood volume in the rat is not the same as it is in humans.

REFERENCES

1. Fernandez L A, Rettori O, Mejia RH. Correlation between body fluid volumes and body weight in the rat. Am. J. Physiol. 1966; 210:877-879.
2. Garcia, JF. Radioiron time-distribution studies at various ages in the normal male rat. Am. J. Physiol. 1957; 190:31-36.
3. Gazenko OG, Genin AM, Ilyin EA, Oganov VS, Serova LV. Adaptation to weightlessness and its physiological mechanisms. Physiologist. 1980; 23(Suppl.):S11-15.
4. Huntoon CL, Whitson PA, Sam CF. Hematologic and immunologic function. In: Nicogossian A.E, Huntoon, CL, Pool AL, ed. Space Physiology and Medicine. Lea & Febiger, Philadelphia, 1994: 351-362.
5. Ilyin EA, Serova LV, Portugalov VV, Tigranyan RA, Savina EA, Gayevskaya MS, Kondratyev YI, Noskin AD, Milyavsky VI, Yurov BN. Preliminary results of examinations of rats after a 22-day flight aboard the Cosmos-605 biosatellite. Aviat. Space Environ. Med. 1975; 46:319-321.
6. Lange RD, Andrews RB, Gibson LA, Congdon CC, Wright P, Dunn CD, Jones JB. Hematological measurements in rats flown on Spacelab shuttle, SL-3. Am J Physiol. 1987; 252:R216-221.
7. Lange RD, Gibson LA, Driscoll TB, Allebban Z, Ichike AT. Effects of microgravity and increased gravity on bone marrow of rats. Aviat. Space Environ. Med. 1994; 65:730-735.
8. Leach CS, Johnson PC. Influence of spaceflight on erythrokinetics in man. Science. 1984; 225:216-218.
9. Lee HB, Blaufox MD. Blood volume in the rat. J.Nucl. Med. 1985; 25:72-76.
10. Leon AL, Serova LV, Cummins J, Landaw SA. Alterations in erythrocyte survival parameters in rats after 19.5 days aboard Cosmos 782. Aviat. Space Environ. Med. 1978; 49:66-69.
11. Leon AL, Serova LV, Landaw SA. Effect of weightlessness and centrifugation on red cell survival in rats subjected to spaceflight. Aviat. Space Environ. Med. 1980; 51:1091-1094.
12. Lombardi MH, Ray GA. Microtechnique for the study of ferro- and erythrokinetics in the rat. AM. J. Vet. Res. 1973; 34:253-259.
13. Nachtman RG, Dunn CDR, Driscoll TB, Leach CS. Methods for repetitive measurements of multiple hematological parameters in individual rats. Lab Animal Sci. 1985; 35:505-508.

14. Nachtman RG, Driscoll TB, Gibson LA, Johnson PC. Commercial over-the-needle catheters for intravenous injections and blood sampling in rats. Lab Animal Sci. 1988; 38:629-630.
15. Thorton WE, Hoffler GW, Rummel JA. Anthropometric changes and fluid shifts. In: Johnston RS, Dietlein LF, Berry CA, ed. Biomedical Results From Skylab. 1977: NASA SP-377; 330-338.
16. Udden MM, Driscoll TB, Pickett MH, Leach-Huntoon CS, Alfrey CP. Decreased production of red blood cells in human subjects exposed to microgravity. J. Lab. Clin. Med. 1995; 125:442-449.
17. Udden MM, Driscoll TB, Gibson LA, Patton CS, Pickett MH, Jones JB, Nachtman R, Allebban A, Ichike AT, Lange RD, Alfrey CP. Blood volume and erythropoiesis in the rat during spaceflight. Aviat. Space Environ. Med. 1995; 66:557-61.
18. Vacek A, Tkadlecek L, Shgvets VN, Bartonickova A, Viklicka S, Rotovska D, Serova LV, Michurinal TV. Space flight effects on haemopoietic stem cells of the bone marrow of rats. Cell Tissue Kinet. 1982;15:643-649.

FIGURE LEGENDS

Figure 1. Growth curves for animals from 22 days prior to launch through landing day (R+0). Values are Mean ± SE; n = 10. During the mission and on landing day there was a significant difference between the flight means and the ground control means as shown by Repeated Measurements ANOVA and Bonferroni - Dunn test with $p \leq 0.05$.

Figure 2. **A.** RBCM as absolute volume; **B.** PV as absolute volume; **C.** RBCM normalized for body weight; **D.** PV normalized for body weight. Values are Mean ± SE; n = 10. The (*) indicates a significant difference between the flight mean and the ground control mean as shown by Repeated Measurements ANOVA and Bonferroni - Dunn test with $p \leq 0.05$.

Figure 3. Plasma volume normalized for body weight. Values are Mean ± SE; n = 5. Repeated Measurements ANOVA showed no significant difference related to spaceflight.

Figure 4. Percentage ^{59}Fe incorporated into total circulating RBCs after FD6 injection. Values are Mean ± SE; n = 5. Values for both groups at 24 hours and 9 days were within the normal range and no difference was found between ground control and flight animals.

Figure 5. Percentage ^{59}Fe incorporated into total circulating RBCs after FD9 injection. Values are Mean ± SE; n = 5 (exception n=3 for saline injected flight animals). The (*) indicates a significant difference between the 24-hour ground control mean and all other 24-hour means as shown by One Factor ANOVA and Bonferroni - Dunn test with $p \leq 0.05$. The (**) indicates a significant difference between the EPO injected and saline injected flight animals at 24 hours as shown by the Mann-Whitney U test with $p \leq 0.05$.

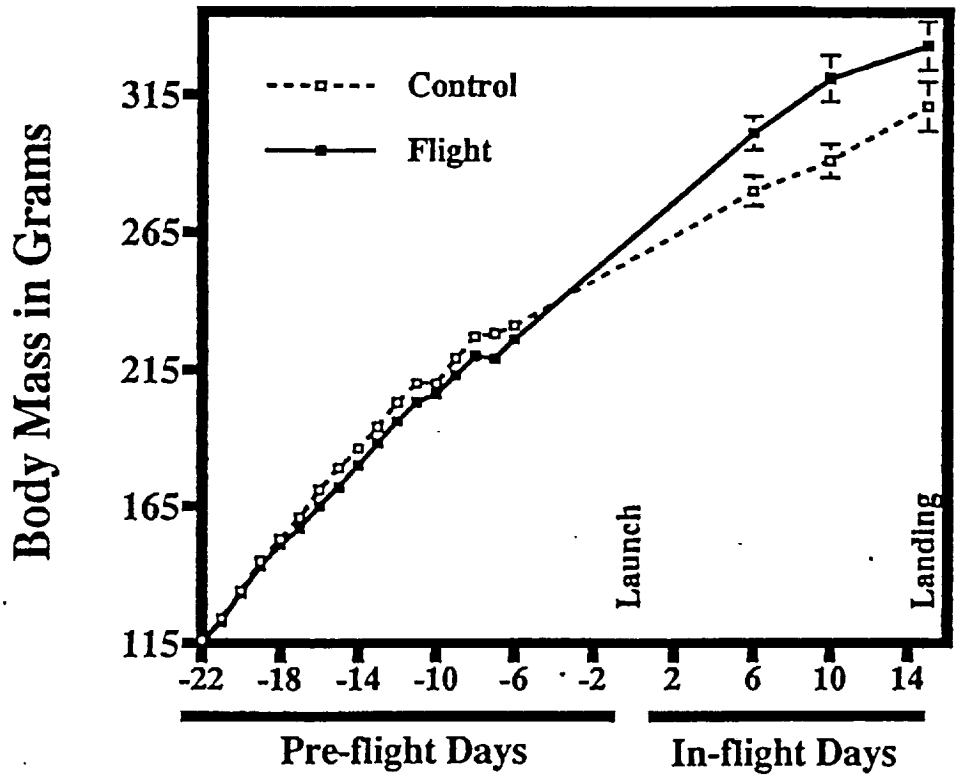
Body Mass in Grams
315
265
215
165
115
Control
Flight
Launch
Landing
-22
-18
-14
-10
-6
-2
2
6
10
14
Pre-flight Days
In-flight Days

Figure 1

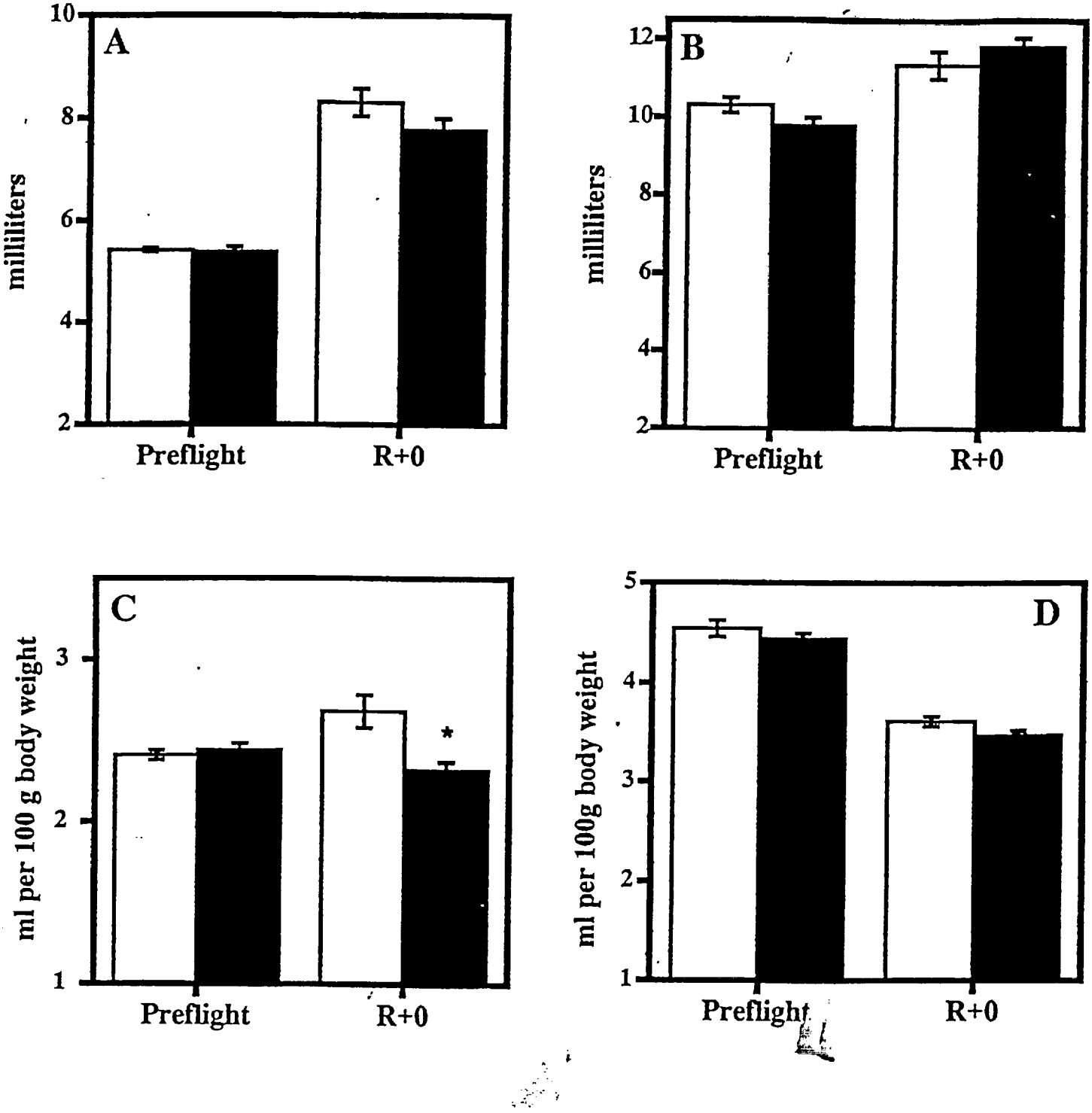
A
B
C
D
milliliters
ml per 100 g body weight
ml per 100g body weight
Preflight
R+0
*

Figure 2

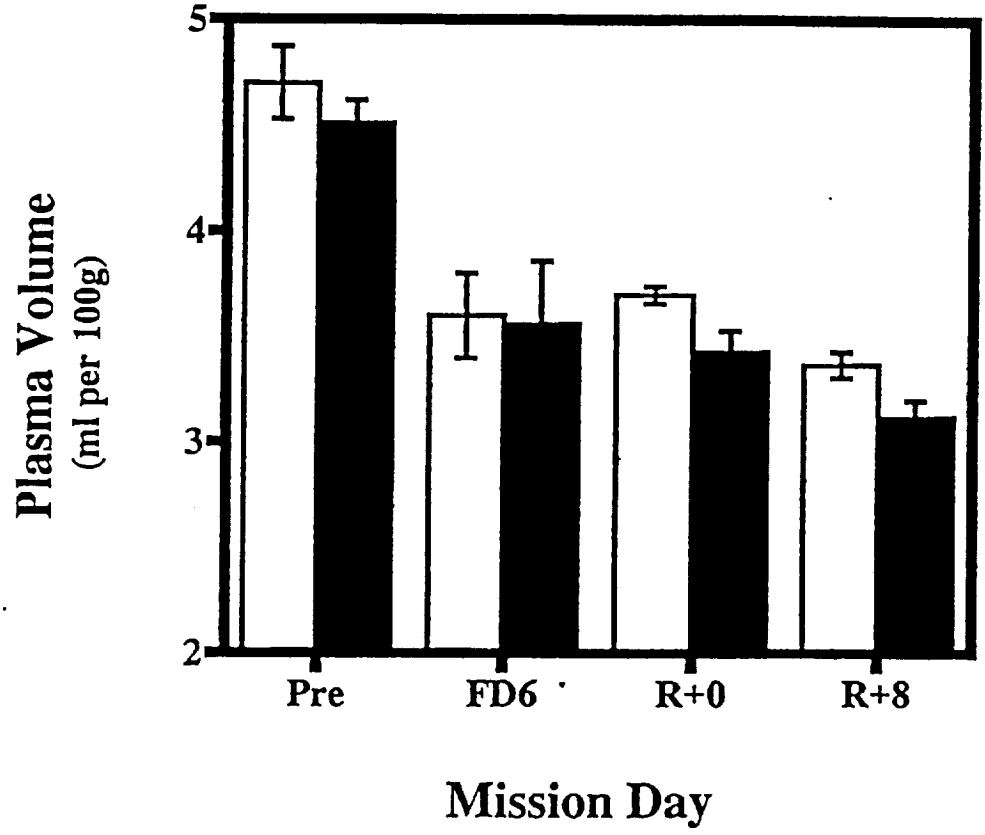

Figure 3

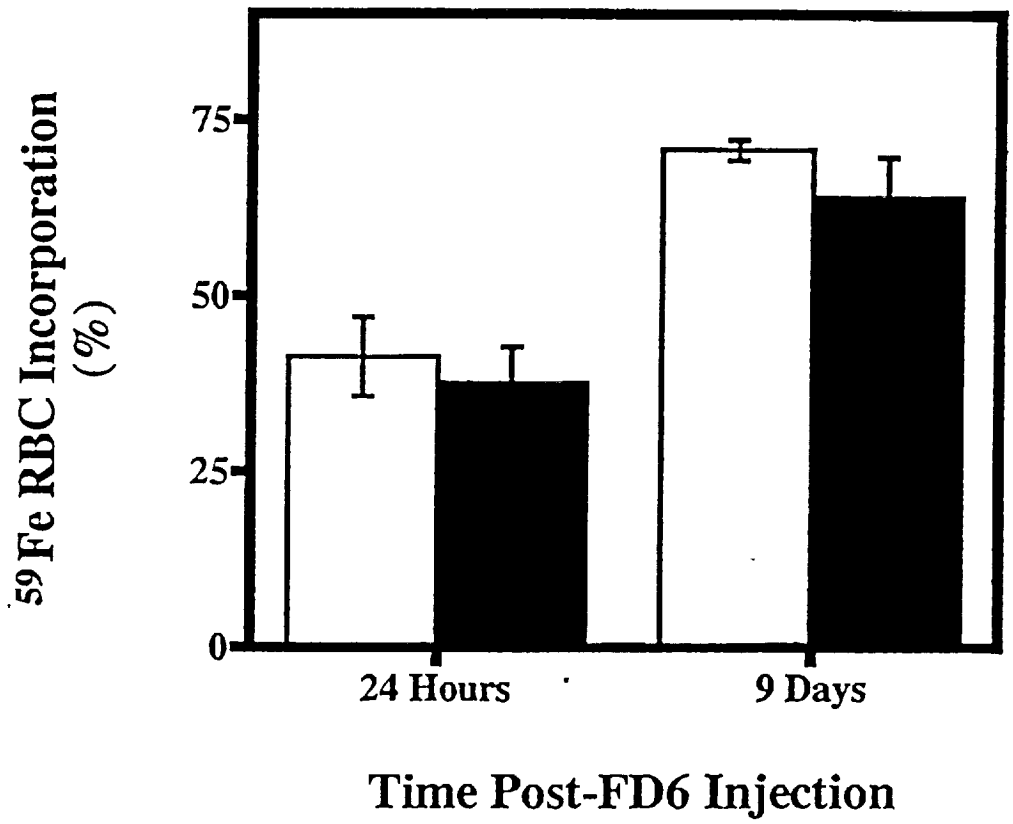
^{59}Fe RBC Incorporation (%)
75
50
25
0
24 Hours
9 Days
Time Post-FD6 Injection

Figure 4

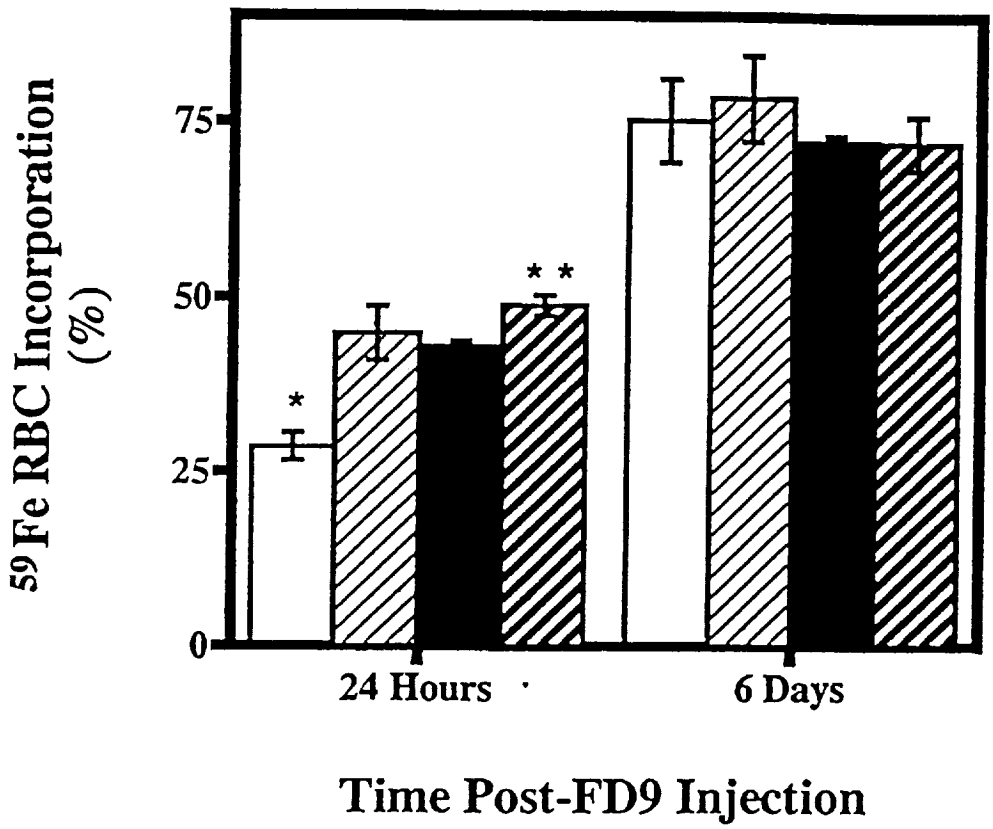
59 Fe RBC Incorporation (%)
75
50
25
0
*
* *
24 Hours
6 Days
Time Post-FD9 Injection

Figure 5

Body Mass On Days When Radionuclide Measurements Were Made
grams

		FLIGHT ANIMALS					GROUND CONTROL ANIMALS					
	I.D.	L-7	FD6	FD10	R+0	R+8	I.D.	L-7	FD6	FD10	R+0	R+8
Group 1	14	228	316	353	346	327	20	231	315	327	357	385
	76	228	326	328	348	350	66	223	272	265	252	294
	13	206	290	298	313	321	72	209	290	286	302	323
	18	211	297	320	330	338	17	239	253	282	321	363
	24	211	305	330	347	343	16	230	278	297	316	371
Group 2	28	227	320	355	371		73	228	286	295	317	
	29	203	270	276	281		74	222	263	269	301	
	58	243	318	348	365		54	233	275	313	341	
	3	211	286	308	314		59	231	291	298	313	
	83	225	276	297	316		62	230	275	280	294	
Group 3	27	237	337	356	373		2	234	285	313	351	
	30	209	300	328	347		10	239	320	344	382	
	51	235	327	349	367		53	215	286	301	313	
	68	222	294	319	333		57	233	297	325	355	
	81	230	323	345	359		61	236	308	319	345	
Group 1	Mean	217	307	326	337	336		227	281	291	309	347
	SE	5	7	9	7	5		5	10	10	17	17
Group 2	Mean	222	294	317	329			229	278	291	313	
	SE	7	11	15	17			2	5	8	8	
Group 3	Mean	227	316	339	356			232	299	320	349	
	SE	5	8	7	7			4	7	7	11	
Group 1, 2, 3	Mean	222	306	327	341			229	286	301	324	
	SE	3	5	6	7			2	5	6	8	
Group 1, 2	Mean	219	301	321	333			228	280	291	311	
	SE	4	6	8	9			3	5	6	9	

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

PLASMA VOLUME
milliters

	FLIGHT ANIMALS					GROUND CONTROL ANIMALS				
	I.D.	L-7	FD6	R+0	R+8	I.D.	L-7	FD6	R+0	R+8
Group 1	14	10.80	11.37	13.20	9.85	20	10.99	13.22	15.20	13.56
	76	9.50	7.92	12.60	12.00	66	9.75	8.92	10.10	9.40
	13	9.76	12.09	13.80	9.79	72	10.94	10.10	12.30	11.15
	18	9.62	11.09	11.90	10.44	17	11.59	7.96	13.40	12.43
	24	9.14	11.81	13.30	10.36	16	9.85	10.87	13.60	12.10
Group 2	28	9.87		15.80		73	9.97		12.10	
	29	8.54		11.60		74	9.39		13.40	
	58	11.24		13.80		54	10.97		14.60	
	3	9.34		13.10		59	9.82		11.70	
	83	9.57		12.50		62	9.81		11.40	
Group 3	27	-		14.10		2	10.87		14.20	
	30	8.74		12.60		10	11.05		14.50	
	51	10.84		14.40		53	10.27		12.50	
	68	10.10		14.20		57	9.86		14.40	
	81	10.07		13.30		61	10.69		14.30	
Group 1	Mean	9.76	10.86	12.96	10.49		10.62	10.21	12.92	11.73
	SE	0.28	0.75	0.33	0.40		0.36	0.90	0.84	0.70
Group 2	Mean	9.71		13.36			9.99		12.64	
	SE	0.44		0.71			0.26		0.60	
Group 3	Mean	9.94		13.72			10.55		13.98	
	SE	0.44		0.34			0.22		0.37	
Group 1, 2, 3	Mean	9.80		13.35			10.39		13.18	
	SE	0.21		0.28			0.17		0.37	
Group 1, 2	Mean	9.74		13.16			10.31		12.78	
	SE	0.25		0.37			0.23		0.49	

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

PLASMA VOLUME
ml per 100 g body weight

	FLIGHT ANIMALS					GROUND CONTROL ANIMALS				
	I.D.	L-7	FD6	R+0	R+8	I.D.	Pre	FD6	Landing	R+8
Group 1	14	4.74	3.60	3.82	3.52	20	4.76	4.20	4.26	3.01
	76	4.17	2.42	3.62	3.20	66	4.37	3.28	4.00	3.43
	13	4.74	4.17	4.39	3.45	72	5.23	3.48	4.08	3.05
	18	4.56	3.73	3.59	3.42	17	4.85	3.15	4.17	3.09
	24	4.33	3.87	3.82	3.26	16	4.28	3.91	4.29	3.02
Group 2	28	4.35		4.26		73	4.37		3.81	
	29	4.21		4.11		74	4.23		4.46	
	58	4.62		3.78		54	4.71		4.27	
	3	4.43		4.17		59	4.25		3.74	
	83	4.25		3.95		62	4.26		3.90	
Group 3	27			3.78		2	4.65		4.06	
	30	4.18		3.65		10	4.62		3.79	
	51	4.61		3.91		53	4.78		4.00	
	68	4.55		4.26		57	4.23		4.05	
	81	4.38		3.70		61	4.53		4.14	
Group 1		**4.51**	**3.56**	**3.85**	**3.37**		**4.70**	**3.60**	**4.16**	**3.12**
		0.11	**0.30**	**0.14**	**0.06**		**0.17**	**0.20**	**0.05**	**0.08**
Group 2		**4.37**		**4.05**			**4.36**		**4.04**	
		0.07		**0.09**			**0.09**		**0.14**	
Group 3		**4.43**		**3.86**			**4.56**		**4.01**	
		0.10		**0.11**			**0.09**		**0.06**	
Group 1, 2, 3		**4.44**		**3.92**			**4.54**		**4.07**	
		0.05		**0.07**			**0.08**		**0.05**	
Group 1, 2,		**4.44**		**3.95**			**4.53**		**4.10**	
		0.07		**0.09**			**0.11**		**0.07**	

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

RED BLOOD CELL MASS
milliliters

	FLIGHT ANIMALS			GROUND CONTROL ANIMALS		
	I.D.	L-7	R+0	I.D.	L-7	R+0
Group 1	14	5.98	8.59	20	5.30	8.65
	76	5.35	8.64	66	5.47	6.99
	13	5.15	6.87	72	5.38	7.62
	18	4.92	7.89	17	5.58	7.33
	24	5.56	7.00	16	5.68	7.14
Group 2	28	5.27	8.80	73	5.39	8.40
	29	5.07	6.39	74	5.28	8.55
	58	5.61	7.54	54	5.52	9.88
	3	4.94	7.43	59	5.14	9.66
	83	5.99	7.21	62	5.47	7.44
Group 3	27		9.79	2	5.64	8.58
	30	4.73	6.85	10	5.44	9.14
	51	5.99	8.23	53	5.49	11.78
	68	5.47	8.03	57	5.67	8.70
	81	5.40	9.30	61	6.34	9.94
Group 1	Mean	5.39	7.80	Mean	5.48	7.55
	SE	0.18	0.38	SE	0.07	0.30
Group 2	Mean	5.38	7.47	Mean	5.36	8.79
	SE	0.19	0.39	SE	0.07	0.45
Group 3	Mean	5.40	8.44	Mean	5.72	9.63
	SE	0.26	0.51	SE	0.16	0.59
Group 1, 2, 3	Mean	5.39	7.90	Mean	5.52	8.65
	SE	0.11	0.25	SE	0.07	0.34
Group 1, 2	Mean	5.38	7.64	Mean	5.42	8.17
	SE	0.12	0.26	SE	0.05	0.33

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

RED BLOOD CELL MASS
milliliters per 100 grams body weight

	FLIGHT ANIMALS			GROUND CONTROL ANIMALS		
	I.D.	L-7	R+0	I.D.	L-7	R+0
Group 1	14	2.62	2.48	20	2.29	2.42
	76	2.35	2.48	66	2.46	2.77
	13	2.50	2.20	72	2.58	2.52
	18	2.33	2.39	17	2.33	2.28
	24	2.63	2.02	16	2.47	2.26
Group 2	28	2.32	2.37	73	2.37	2.65
	29	2.50	2.28	74	2.38	2.84
	58	2.31	2.06	54	2.37	2.90
	3	2.34	2.37	59	2.22	3.09
	83	2.66	2.28	62	2.38	2.53
Group 3	27		2.62	2	2.41	2.45
	30	2.26	1.97	10	2.28	2.39
	51	2.55	2.27	53	2.56	3.76
	68	2.46	2.41	57	2.44	2.45
	81	2.35	2.59	61	2.69	2.88
Group 1	Mean	2.49	2.31	Mean	2.43	2.45
	SE	0.06	0.09	SE	0.05	0.09
Group 2	Mean	2.43	2.27	Mean	2.34	2.80
	SE	0.07	0.06	SE	0.03	0.10
Group 3	Mean	2.41	2.37	Mean	2.48	2.79
	SE	0.06	0.12	SE	0.07	0.26
Group 1, 2, 3	Mean	2.44	2.32	Mean	2.42	2.68
	SE	0.04	0.05	SE	0.03	0.10
Group 1,2	Mean	2.46	2.29	Mean	2.39	2.63
	SE	0.05	0.05	SE	0.03	0.09

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

BLOOD VOLUME
milliliters

	FLIGHT ANIMALS			GROUND CONTROL ANIMALS		
	I.D.	L-7	R+0	I.D.	L-7	R+0
Group 1	14	16.78	20.65	20	16.29	22.06
	76	14.85	20.59	66	15.22	16.05
	13	14.91	18.83	72	16.32	18.87
	18	14.54	18.44	17	17.17	19.56
	24	14.70	18.91	16	15.53	19.23
Group 2	28	15.14	22.79	73	15.36	19.40
	29	13.61	16.76	74	14.67	20.75
	58	16.85	20.08	54	16.49	23.00
	3	14.28	19.01	59	14.96	20.12
	83	15.56	18.27	62	15.28	17.47
Group 3	27		22.64	2	16.52	21.19
	30	13.47	18.31	10	16.49	22.21
	51	16.83	20.97	53	15.76	23.11
	68	15.57	20.36	57	15.53	22.00
	81	15.47	20.62	61	17.03	23.20
Group 1	Mean	15.16	19.48	Mean	16.11	19.15
	SE	0.41	0.47	SE	0.34	0.96
Group 2	Mean	15.09	19.38	Mean	15.35	20.15
	SE	0.56	1.01	SE	0.31	0.90
Group 3	Mean	15.34	20.58	Mean	16.27	22.34
	SE	0.69	0.69	SE	0.27	0.37
Group 1, 2, 3	Mean	15.18	19.82	Mean	15.91	20.55
	SE	0.29	0.43	SE	0.20	0.55
Group 1, 2	Mean	15.12	19.43	Mean	15.73	19.65
	SE	0.33	0.53	SE	0.25	0.64

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

BLOOD VOLUME
milliliters PER 100 gram body mass

	FLIGHT ANIMALS			GROUND CONTROL ANIMALS		
	I.D.	L-7	R+0	I.D.	L-7	R+0
Group 1	14	7.36	5.97	20	7.05	6.18
	76	6.51	5.92	66	6.83	6.37
	13	7.24	6.02	72	7.81	6.25
	18	6.89	5.59	17	7.18	6.09
	24	6.97	5.45	16	6.75	6.09
Group 2	28	6.67	6.14	73	6.74	6.12
	29	6.70	5.96	74	6.61	6.89
	58	6.93	5.50	54	7.08	6.74
	3	6.77	6.05	59	6.48	6.43
	83	6.92	5.78	62	6.64	5.94
Group 3	27	-	6.07	2	7.06	6.04
	30	6.44	5.28	10	6.90	5.81
	51	7.16	5.71	53	7.33	7.38
	68	7.01	6.11	57	6.67	6.20
	81	6.73	5.74	61	7.22	6.72
Group 1	Mean	6.99	5.79	Mean	7.12	6.20
	SE	0.15	0.11	SE	0.19	0.05
Group 2	Mean	6.80	5.89	Mean	6.71	6.43
	SE	0.05	0.11	SE	0.10	0.18
Group 3	Mean	6.84	5.78	Mean	7.03	6.43
	SE	0.16	0.15	SE	0.12	0.28
Group 1, 2, 3	Mean	6.88	5.82	Mean	6.96	6.35
	SE	0.07	0.07	SE	0.09	0.11
Group 1, 2	Mean	6.90	5.84	Mean	6.92	6.31
	SE	0.08	0.08	SE	0.12	0.10

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

CENTRIFUGED HEMATOCRIT EXPRESSED AS PERCENTAGE

FLIGHT ANIMALS

Day		L-7				L-6		FD6				FD7		FD9		FD10		FD14		R+0				R+2		R+4		R+6		R+8			
Blood Sample		1		2		1		1		2		1		1		1		1		1		2		1		1		1		1		2	
Duplication		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	I.D.																																
Group 1	14	48	48	45	43	44	43	53	53	50	52	49	49					52	52	53	53	51	50	50	50	51	51	52	52	59	60	57	57
	76	48	50	44	45	44	45	59	62	58	58	49	49					50	51	56	56	49	*	54	55	52	52	49	49	52	53	52	52
	13	44	44	44	45	42	43	46	46	43	43	40	40					44	46	48	49	45	46	54	54	47	46	48	48	50	51	56	56
	18	44	44	44	45	45	44	49	49	47	49	49	50					56	57	49	49	50	50	50	50	50	50	56	55	53	53	52	52
	24	47	46	48	47	53	52	51	51	49	50	49	49					54	54	51	50	46	48	54	55	52	52	60	60	57	58	59	60
Group 2	28	45	46	44	44	43	44							50	49	48	48			51	52	48	50										
	29	45	44	46	46	45	45							*	*	46	46			49	50	45	46										
	58	45	45	42	42	43	43							50	50	47	48			51	50	46	46										
	3	43	44	45	45	42	41							48	48	52	53			50	50	47	48										
	83	44	45	45	47	44	45							50	51	51	51			49	49	49	*										
Group 3	27	46	46	47	46	44	45							53	56	50	50			50	49	49	48										
	30	47	48	46	45	51	51							48	48	48	49			49	50	45	48										
	51	47	47	45	44	42	43							50	51	55	55			52	52	49	49										
	68	46	46	44	44	42	41							52	52	50	49			49	49	48	49										
	81	48	46	43	43	43	44							50	50	53	52			47	50	51	50										
Group 1	Mean	46.3		45.0		45.5		51.9		49.9		47.3						51.6		51.4		48.3		52.6		50.3		52.9		54.6		55.3	
	SE	1.0		0.6		1.8		2.4		2.4		1.8						1.9		1.4		0.9		1.1		1.0		2.2		1.7		1.5	
Group 2	Mean	44.6		44.6		43.5								49.5		49.0				50.1		47.2											
	SE	0.3		0.7		0.6								0.5		1.2				0.4		0.7											
Group 3	Mean	46.7		44.7		44.6								50.3		51.4				49.7		48.6											
	SE	0.4		0.6		1.7								1.1		1.2				0.6		0.6											
Group 1,2,3	Mean	45.9		44.8		44.5														50.4		48.1											
	SE	0.4		0.4		0.8														0.5		0.4											
Group 1,2	Mean	45.5		44.8		44.9														50.8		47.8											
	SE	0.6		0.5		1.0														0.7		0.6											

Groups
1. 125-I Albumin&59-Fe injection FD6
2. 59-Fe and saline injection FD9
3. 59-Fe and EPO injection FD9
Saline dilutent - total volume 1.2 ml

Two blod sample days
10 minutes between samples
1. Withdrawn through Catheter
2. Withdrawn through needle

Single blood sample days
withdrawn through needle

CENTRIFUGED HEMATOCRIT EXPRESSED AS PERCENTAGE
GROUND CONTROL ANIMALS

Day		L-7				L-6		FD6				FD7		FD9		FD10		FD14		R+0				R+2		R+4		R+6		R+8			
Blood Sample		1		2		1		1		2		1		1		1		1		1		2		1		1		1		1		2	
Duplication		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	I.D.																																
Group 1	20	44	44	41	41	42	42	45	45	44	44	49	48					53	53	51	51	48	48	48	49	48	48	52	52	47	48	47	48
	66	50	49	45	SA	44	44	54	*	54	54	54	54					55	54	59	59	54	54	54	55	56	56	53	53	52	52	53	54
	72	44	44	41	42	43	43	54	55	49	50	53	53					58	59	52	52	48	50	52	53	52	51	51	53	54	54	52	51
	17	42	42	42	42	40	41	55	55	53	53	46	47					53	53	50	49	46	47	52	52	54	53	48	49	46	48	47	47
	16	53	54	47	48	43	43	51	*	44	44	46	47					53	53	50	49	46	47	48	48	52	52	50	50	51	51	47	47
Group 2	73	45	46	48	48	52	52							55	55	52	52			53	*	50	51										
	74	49	50	49	48	43	42							55	56	50	50			50	50	46	47										
	54	41	40	42	40	43	44							49	49	48	49			50	50	48	47										
	59	45	45	43	43	41	40							52	52	56	56			51	50	50	51										
	62	47	46	44	45	54	54							55	55	53	53			54	54	51	52										
Group 3	2	47	47	46	47	44	43							55	55	55	55			52	*	50	50										
	10	44	45	43	43	40	40							51	51	53	52			52	52	48	49										
	53	50	47	45	46	41	42							56	55	51	51			54	54	52	52										
	57	49	48	45	45	41	40							51	51	54	55			55	55	50	50										
	61	47	47	45	46	45	45							55	55	59	59			54	55	50	50										
Group 1	Mean	46.6		43.2		42.5		51.8		48.9		49.7						54.4		52.2		48.8		51.1		52.2		51.1		50.3		49.3	
	SE	2.1		1.2		0.6		1.9		2.1		1.6						1.1		1.8		1.4		1.2		1.3		0.8		1.3		1.3	
Group 2	Mean	45.4		45.0		46.5								53.3		51.9				51.3		49.3											
	SE	1.5		1.4		2.7								1.2		1.3				0.8		1.0											
Group 3	Mean	47.1		45.1		42.1								53.7		53.5				53.7		50.1											
	SE	0.7		0.6		0.9								1.0		1.4				0.6		0.6											
Group 1,2,3	Mean	46.4		44.5		43.7														52.4		49.4											
	SE	0.8		0.6		1.0														0.1		0.6											
Group 1,2	Mean	46.0		44.2		45.1														51.8		49.1											
	SE	1.2		0.9		1.5														0.9		0.8											

Groups
1. 125-I Albumin&59-Fe injection FD6
2. 59-Fe and saline injection FD9
3. 59-Fe and EPO injection FD9
Saline dilutent - total volume 1.2 ml

Two blod sample days
10 minutes between samples
1. Withdrawn through Catheter
2. Withdrawn through needle

Single blood sample days
withdrawn through needle

Total Body Hematocrit
Percentage

	FLIGHT ANIMALS			GROUND CONTROL ANIMALS		
	I.D.	L-7	R+0	I.D.	L-7	R+0
Group 1	14	35.6	42.2	20	32.5	40.1
	76	36.0	44.0	66	35.9	44.4
	13	34.5	37.2	72	33.0	41.0
	18	33.8	42.4	17	32.5	38.2
	24	37.8	37.8	16	36.6	37.8
Group 2	28	34.8	39.3	73	35.1	44.0
	29	37.3	39.0	74	36.0	42.4
	58	33.3	38.6	54	33.5	43.8
	3	34.6	39.6	59	34.4	47.9
	83	38.5	39.3	62	35.8	43.1
Group 3	27		43.5	2	34.2	41.0
	30	35.1	38.0	10	33.0	42.3
	51	35.6	40.3	53	34.8	51.8
	68	35.1	39.4	57	36.5	40.9
	81	34.9	44.2	61	37.2	44.3
Group 1	Mean	35.6	40.7	Mean	34.1	40.3
	SE	0.7	1.4	SE	0.9	1.2
Group 2	Mean	35.7	39.2	Mean	34.9	44.2
	SE	0.9	0.2	SE	0.5	1.0
Group 3	Mean	35.2	41.1	Mean	35.2	44.1
	SE	0.1	1.2	SE	0.8	2.0
Group 1, 2, 3	Mean	35.5	40.3	Mean	34.7	42.9
	SE	0.4	0.6	SE	0.4	0.9
Group 1, 2	Mean	35.6	39.9	Mean	34.5	42.3
	SE	0.6	0.7	SE	0.5	1.0

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

Total Body to Peripheral Hematocrit Ratio

	FLIGHT ANIMALS			GROUND CONTROL ANIMALS		
	I.D.	L-7	R+0	I.D.	L-7	R+0
Group 1	14	0.77	0.82	20	0.77	0.81
	76	0.77	0.84	66	0.76	0.79
	13	0.78	0.79	72	0.77	0.81
	18	0.77	0.86	17	0.77	0.80
	24	0.80	0.77	16	0.72	0.79
Group 2	28	0.78	0.78	73	0.75	0.85
	29	0.82	0.82	74	0.73	0.88
	58	0.77	0.80	54	0.82	0.90
	3	0.78	0.81	59	0.78	0.95
	83	0.85	0.80	62	0.79	0.82
Group 3	27		0.89	2	0.73	0.80
	30	0.76	0.79	10	0.75	0.84
	51	0.78	0.80	53	0.74	0.98
	68	0.78	0.81	57	0.78	0.78
	81	0.78	0.89	61	0.81	0.85
Group 1	Mean	0.78	0.81	Mean	0.76	0.80
	SE	0.01	0.01	SE	0.01	0.01
Group 2	Mean	0.80	0.80	Mean	0.77	0.88
	SE	0.02	0.01	SE	0.02	0.02
Group 3	Mean	0.77	0.84	Mean	0.76	0.85
	SE	0.01	0.02	SE	0.01	0.03
Group 1, 2, 3	Mean	0.78	0.82	Mean	0.77	0.84
	SE	0.01	0.01	SE	0.01	0.02
Group 1, 2	Mean	0.79	0.81	Mean	0.77	0.84
	SE	0.01	0.01	SE	0.01	0.02

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

IRON INCORPORATION INTO RED BLOOD CELLS

% 59-Fe in Total Red Blood Cell Mass

FLIGHT ANIMALS			GROUND CONTROL ANIMALS		
Group 1 - 59-Fe Injection on FD6					
I.D.	FD7 24 Hours	R+0 9Days	I.D.	FD7 24 Hours	R+0 9Days
14	20.5	76.9	20	53.1	74.7
76	43.4	64.4	66	26.9	66.4
13	51.1	59.2	72	39.7	70.2
18	40.6	75.3	17	32.7	68.6
24	34.3	61.3	16	55.8	68.7
Mean	**38.0**	**67.4**	Mean	**41.6**	**69.7**
SE	**5.1**	**3.6**	SE	**5.6**	**1.4**
Group 2 - 59-Fe and Saline Injection on FD9					
I.D.	FD10 24 Hours	R+0 6 Days	I.D.	FD10 24 Hours	R+0 6 Days
28	42.2	69.7	73	36.4	74.1
29			74	26.3	69.2
58			54	30.9	74.8
3	43.1	72.6	59	24.7	77.7
83	44.8	72.7	62	27.6	69.2
Mean	**43.4**	**71.7**	Mean	**29.2**	**73.0**
SE	**0.8**	**1.0**	SE	**2.1**	**1.7**
Group 3 - 59-Fe and Erythropoietin Injection on FD9 (200 Units EPO)					
I.D.	FD10 24 Hours	R+0 6 Days	I.D.	FD10 24 Hours	R+0 6 Days
27	48.9	77.7	2	35.7	66.4
30	50.5	62.0	10	52.0	75.2
51	49.7	64.2	53	36.9	99.8
68	43.9	70.6	57	50.5	70.5
81	53.0	84.7	61	46.8	84.9
Mean	**49.2**	**71.8**	Mean	**44.4**	**79.4**
SE	**1.5**	**4.2**	SE	**3.4**	**6.0**

51-Cr RED BLOOD SURVIVAL
T1/2 in Days

	FLIGHT ANIMALS			GROUND CONTROL ANIMALS		
	I.D.	L-6 to R+0	R+1 to R+8	I.D.	L-6 to R+0	R+1 to R+8
Group 1	14	21.0	18.9	20	21.5	17.9
	76	21.0	17.7	66	17.2	18.7
	13	18.0	16.9	72	17.0	22.9
	18	21.5	20.3	17	23.2	18.0
	24	18.2	22.1	16	18.2	19.3
Group 2	28	18.4		73	17.6	
	29	18.5		74	18.1	
	58	23.8		54	17.8	
	3	20.6		59	20.9	
	83	17.6		62	16.9	
Group 3	27			2	20.1	
	30	23.0		10	19.4	
	51	18.0		53	19.5	
	68	22.0		57	17.6	
	81	23.5		61	17.7	
Group 1	Mean	19.9	19.2	Mean	19.4	19.4
	SE	0.8	0.9	SE	1.2	0.9
Group 2	Mean	19.8		Mean	18.3	
	SE	1.1		SE	0.7	
Group 3	Mean	21.6		Mean	18.9	
	SE	1.2		SE	0.5	
Group 1, 2, 3	Mean	20.4		Mean	18.8	
	SE	0.6		SE	0.5	
Group 1, 2	Mean	19.9		Mean	18.8	
	SE	0.6		SE	0.7	

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

51-CR SPLEEN TO LIVER RATIO

	FLIGHT ANIMALS		GROUND CONTROL ANIMALS	
	I.D.	R+9	I.D.	R+9
Group 1	14	1.58	20	3.02
	76	1.46	66	2.97
	13	2.84	72	2.63
	18	2.55	17	2.99
	24	2.73	16	1.98
	Mean	2.23		2.72
	SE	0.29		0.20
	RAT #	R+0	RAT #	R+0
Group 2	28	1.36	73	1.32
	29	1.34	74	1.32
	58	1.14	54	1.43
	3	1.93	59	1.34
	83	2.23	62	2.32
	Mean	1.60		1.54
	SE	0.21		0.20
Group 3	27		2	1.37
	30	1.64	10	0.46
	51	2.40	53	0.56
	68	1.13	57	1.38
	81	2.04	61	1.17
	Mean	1.80	Mean	0.99
	SE	0.27	SE	0.20

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

EOCHINOCYTE COUNT

% of Total RBC Count

		FLIGHT ANIMALS								GROUND CONTROL ANIMALS								
	I.D.	L-7	L-6	FD6	FD7	FD9	FD10	R+0	R+6	I.D.	L-7	L-6	FD6	FD7	FD9	FD10	R+0	R+6
Group 1	14	0.10	0.55	2.05	2.18			0.20	0.10	20	6.75	6.35	12.25	10.85			7.11	1.70
	76	1.30	0.76	1.75	8.85			0.05	0.45	66		3.35	2.10	4.40			3.25	2.45
	13	1.80	2.10	1.05	5.24			0.05	0.60	72	0.60		2.50	3.90			2.55	1.05
	18	1.35	1.75	3.10	2.90			0.15	1.75	17	1.55	3.05	1.20	7.45			0.85	0.55
	24	3.40	4.03	0.80	1.05			0.04	1.28	16	1.75		1.00	1.45			0.85	0.70
Group 2	28	0.25	0.75			0.97	0.85	0.10		73	0.75	2.25			0.66	1.25		
	29	0.25	1.90			1.20	2.27	0.25		74	0.55	2.60			6.55	3.20	4.85	
	58	2.03	3.10			7.00	3.80	0.05		54	0.80	1.80			0.70	1.15	2.55	
	3	1.85	1.65			1.80	2.49	0.15		59	0.35	4.60			2.20	4.95	4.20	
	83	0.10	0.58			0.35	0.65	0.20		62		0.50			0.65	0.35	0.70	
Group 3	27	0.45	0.58			0.64	0.22	0.13		2	0.55	1.40			2.00	5.65	3.93	
	30	0.20	1.40			5.00	1.55	0.25		10	2.00	1.20			0.85	0.75	1.90	
	51	1.70	2.70			3.10	0.85	0.13		53	0.95	2.70			1.20	1.70	2.70	
	68	0.45	4.32			3.05	2.81	0.00		57	1.35	3.30			1.20	2.20	2.50	
	81	1.05	6.40			2.80	2.45	0.30		61	1.00	4.70			0.50	1.20	1.20	
Group 1	Mean	1.59	1.84	1.75	4.04			0.10	0.84		2.66	4.25	3.81	5.61			2.92	1.29
	SE	0.53	0.62	0.41	1.38			0.03	0.30		1.39	1.05	2.13	1.62			1.15	0.35
Group 2	Mean	0.90	1.60			2.26	2.01	0.15			0.61	2.35			2.15	2.18	3.08	
	SE	0.43	0.45			1.21	0.58	0.04			0.09	0.74			1.14	0.84	0.93	
Group 3	Mean	0.77	3.08			2.92	1.58	0.16			1.17	2.66			1.15	2.30	2.45	
	SE	0.27	1.04			0.69	0.48	0.05			0.27	0.64			0.25	0.87	0.45	
Group 1, 2, 3	Mean	1.09	2.17					0.14			1.46	2.91					2.80	
	SE	0.25	0.44					0.02			0.46	0.45					0.46	
Group 1, 2	Mean	1.24	1.72					0.12			1.64	3.06					2.99	
	SE	0.34	0.36					0.02			0.71	0.56					0.71	

Group 1 — 125-I Albumin and 59-Fe injection on FD6 — Saline dilutent - total volume injected 1.2 ml

Group 2 — 59-Fe and saline injection on FD9 — Saline dilutent - total volume injected 1.2 ml

Group 3 — 59-Fe and EPO injection on FD9 — Saline dilutent - total volume injected 1.2 ml

SERUM FERRITIN
ng/ml

FLIGHT ANIMALS

Rat #	FD13	Rat #	R+0	I.D.	R+9
117	581	28	420	14	475
124	398	29	798	76	358
125	618	58	463	13	241
128	477	3	394	18	307
134	465	83	487	24	474
136	596	27	539		
		30	465		
		51	692		
		68	611		
		81	451		
Mean	523		532		371
SE	36		41		46
Group1 Mean					371
SE					46
Group 2 Mean			512		
SE			52		
Group 3 Mean			552		
SE			32		

GROUND CONTROL ANIMALS

I.D.	L-0	I.D.	FD13	I.D.	R+0	I.D.	R+9
31	387		427	73	483	20	328
33	410		302	74	389	66	358
38	311		322	54	466	72	222
85	467		378	59	432	17	298
86	438		458	62	528	16	363
90	291		541	2	473		
93	324			10	408		
96	375			53	584		
97	351			57	458		
99	220			61	441		
	357		405		466		314
	23		37		18		26
							314
							26
					460		
					17		
					473		
					21		

Group 1 125-I Albumin and 59-Fe injection on FD6 — Saline dilutent - total volume injected 1.2 ml
Group 2 59-Fe and saline injection on FD9 — Saline dilutent - total volume injected 1.2 ml
Group 3 59-Fe and EPO injection on FD9 — Saline dilutent - total volume injected 1.2 ml

PLASMA FERRITIN
ng per dl
GROUND CONTROL ANIMALS

	I.D.	L-7	L-6	FD6	FD7	FD9	FD10	FD14	R+0	R+2	R+4	R+6
Group 1	**20**	278	196	884	707			669	454	258	267	369
	66	309	323	781	1017			715	528	782	583	397
	72	312	632	958	1550			814	433	429	378	249
	17	322	319	1371	1281			729	408	*	442	361
	16	348	525	942	1235			734	668	550	843	473
Group 2	**73**	660	693			921	805		478			
	74	730				1065	748		448			
	54	717	512			933	784		549			
	59	475	244			1006	1121		417			
	62	548	546			1009	826		670			
Group 3	**2**	848	463				1598		498			
	10	404	580			794	730		462			
	53	542	587			1766	1613		595			
	57	446	378			1054	1135		463			
	61	395	486			1146	1637		552			
Group 1	**Mean**	314	399	987	1158			732	498	505	503	370
	SE	11	79	101	141			23	47	99	99	36
Group 2	**Mean**	626	499			987	857		512			
	SE	50	84			27	67		45			
Group 3	**Mean**	527	499			1190	1343		514			
	SE	84	39			184	179		26			
Group 1,2,3	**Mean**	489	463						508			
	SE	46	39						22			
Group 1,2	**Mean**	543	473						520			
	SE	53	52						35			

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

The elevated values for in-flight days may be due to an artifact of sample storage.

PLASMA FERRITIN
ng per dl
FLIGHT ANIMALS

	I.D.	L-7	L-6	FD6	FD7	FD9	FD10	FD14	R+0	R+2	R+4	R+6
Group 1	**14**	585	511	1070	1950			1330	483	376	748	375
	76	491	459	1736	1328			1227	378	422	447	330
	13	604	672	825	1002			739	639	347	410	362
	18	585	664	795	574			654	796	635	565	417
	24	610	884	1242	1322			1359	670	624	452	522
Group 2	**28**	416	321			566	496		424			
	29	555	411			*	647		584			
	58	478	265			688	678		562			
	3	418	409			755	621		494			
	83	548	480			445	743		627			
Group 3	**27**	400	606			1066	531		446			
	30	585	463			581	487		395			
	51	308	462			1277	1696		479			
	68	334	146			1150	1106		434			
	81	712	185			1180	1011		454			
Group 1	**Mean**	575	638	1134	1235			1062	593	481	524	401
	SE	22	74	172	226			151	73	62	62	33
Group 2	**Mean**	483	377			614	637		538			
	SE	30	38			68	41		36			
Group 3	**Mean**	468	372			1051	966		442			
	SE	78	89			122	221		14			
Group 1,2,3	**Mean**	509	463						524			
	SE	29	50						31			
Group 1,2	**Mean**	516	491						594			
	SE	25	68						38			

Group 1	125-I Albumin and 59-Fe injection on FD6	Saline dilutent - total volume injected 1.2 ml
Group 2	59-Fe and saline injection on FD9	Saline dilutent - total volume injected 1.2 ml
Group 3	59-Fe and EPO injection on FD9	Saline dilutent - total volume injected 1.2 ml

The elevated values for in-flight days may be due to an artifact of sample storage.

BODY MASS
FLIGHT ANIMALS
PRE-FLIGHT

	I.D.	L-24	L-23	L-22	L-21	L-20	L-19	L-18	L-17	L-16	L-15	L-14	L-13	L-12	L-11	L-10	L-9	L-8	L-7	L-6	L-2
Group1	14	94	101	116	126	136	147	159	163	170	181	188	198	204	212	216	223	230	228	238	262
	76	95	106	116	123	136	143	151	157	166	174	180	188	197	203	204	214	222	228	228	267
	13	96	107	119	125	131	141	147	152	158	165	171	181	186	191	195	202	208	206	210	240
	18	96	106	114	124	131	141	149	156	161	168	174	181	190	197	201	206	214	211	223	252
	24	93	103	112	118	128	138	148	154	163	171	179	186	193	202	204	213	218	211	222	241
Group 2	28	92	105	116	121	133	145	151	157	167	173	180	189	193	199	207	215	224	227	230	278
	29	99	104	115	121	132	136	144	142	158	165	170	179	183	188	192	198	201	203	212	233
	58	94	104	115	125	136	146	159	167	177	185	194	203	215	220	225	237	241	243	248	266
	3	90	101	111	119	130	139	147	154	160	163	176	184	193	200	201	209	216	211	221	252
	83	97	108	118	127	139	149	157	167	173	180	186	193	203	216	211	221	227	225	232	256
Group 3	27	99	111	123	131	140	149	161	169	177	186	193	200	210	218	216	228	239	237	248	276
	30	95	104	112	120	128	139	148	151	158	166	172	180	183	190	191	199	209	209	209	253
	51	99	107	119	126	139	150	157	164	175	185	188	198	207	212	217	226	232	235	243	282
	68	95	109	119	125	141	151	160	167	175	185	189	200	203	210	211	216	221	222	228	253
	81	91	105	107	120	130	137	147	156	169	176	181	190	201	209	210	221	228	230	233	258
Group 1	Mean	95	105	116	123	132	142	151	157	164	172	179	187	194	201	204	212	219	217	224	252
	SE	1	1	1	1	2	1	2	2	2	3	3	3	3	3	3	4	4	5	5	5
Group 2	Mean	95	104	115	123	134	143	152	158	167	173	181	190	198	205	207	216	222	222	229	257
	SE	2	1	1	1	2	2	3	5	4	4	4	4	5	6	5	6	7	7	6	7
Group 3	Mean	96	107	116	125	136	145	155	162	171	180	185	194	201	208	209	218	226	227	232	264
	SE	1	1	3	2	3	3	3	3	3	4	4	4	5	5	5	5	5	5	7	6
Group 1,2,3	Mean	95	104	115	123	134	143	152	158	167	173	181	190	198	205	207	216	222	222	229	257
	SE	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	3	4	4
Group 1,2	Mean	95	105	115	123	133	143	151	157	165	173	180	188	196	203	206	214	220	219	226	255
	SE	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	4	4	4	4	4

BODY MASS
GROUND CONTROL ANIMALS
DURING FLIGHT AND POST-FLIGHT

	I.D.	FD1	FD2	FD3	FD4	FD5	FD6	FD7	FD8	FD9	FD10	FD11	FD12	FD13	FD14	R+0	R+1	R+2	R+3	R+4	R+5	R+6	R+7	R+8	R+9
Group1	20						315				327					357	361	358		370	369	378	373	385	373
	66						272				265					252	273	265		267	264	285	288	294	288
	72						290				286					302	289	297		304	307	315	308	323	318
	17						253				282					321	320	326		332	336	346	350	363	358
	16						278				297					316	335	332		330	348	352	355	371	361
Group 2	73						286				295					317									
	74						263				269					301									
	54						275				313					341									
	59						291				298					313									
	62						275				280					294									
Group 3	2						285				313					351									
	10						320				344					382									
	53						286				301					313									
	57						297				325					355									
	61						308				319					345									
Group 1							281				291					309	316	315		320	325	335	335	347	339
							10				10					17	16	16		17	18	16	16	17	16
Group 2							278				291					319									
							5				8					6									
Group 3							299				321					349									
							7				7					11									
Group 1,2,3							278				291					313									
							4				6					9									
Group 1,2							280				291					311									
							5				6					9									

Group 1	125-I Albumin and 59-Fe injection on FD6
Group 2	59-Fe and saline injection on FD9
Group 3	59-Fe and EPO injection on FD9

Saline dilutent - total volume injected 1.2 ml

BODY MASS
GROUND CONTROL ANIMALS
PRE-FLIGHT

	I.D.	L-24	L-23	L-22	L-21	L-20	L-19	L-18	L-17	L-16	L-15	L-14	L-13	L-12	L-11	L-10	L-9	L-8	L-7	L-6
Group1	20	93	101	111	121	129	142	152	158	168	175	183	193	201	210	212	221	233	231	242
	66	95	103	118	126	139	146	154	160	169	177	184	191	200	205	206	215	223	223	223
	72	94	111	118	125	136	145	155	161	170	177	186	195	199	214	189	198	208	209	208
	17	102	108	115	125	138	146	157	165	176	185	196	204	213	221	226	237	244	239	250
	16	94	110	120	127	138	149	159	167	176	185	192	201	208	220	217	227	233	230	242
Group 2	73	94	105	116	122	130	143	146	154	168	176	172	188	198	203	205	215	223	228	226
	74	92	106	113	122	128	139	147	155	163	171	179	184	195	200	202	212	221	222	220
	54	93	102	115	124	134	147	157	164	174	182	192	196	211	214	219	226	235	233	240
	59	95	114	122	130	142	152	161	169	179	187	195	199	209	212	217	223	234	231	239
	62	91	101	109	115	126	136	143	153	163	171	178	187	194	201	202	212	220	230	221
Group 3	2	100	110	120	129	139	151	160	171	177	189	197	203	214	222	220	229	238	234	244
	10	94	109	119	126	138	149	159	164	174	187	194	201	207	215	220	232	239	239	247
	53	90	101	111	121	129	136	148	154	163	169	178	182	190	193	196	207	215	215	223
	57	89	102	116	124	135	145	155	163	172	180	187	200	204	215	214	224	232	233	237
	61	93	105	116	129	135	145	153	161	170	181	189	198	207	213	216	226	234	236	243
Group 1	Mean	96	107	117	125	136	146	156	162	172	180	188	197	204	214	210	220	228	227	233
	SE	2	2	2	1	2	1	1	2	2	2	2	2	3	3	6	7	6	5	8
Group 2	Mean	93	106	115	123	132	144	151	159	170	177	183	191	202	206	209	218	227	229	229
	SE	1	2	2	2	3	3	3	3	3	3	4	3	4	3	4	3	3	2	4
Group 3	Mean	93	105	117	126	135	145	155	163	171	181	189	197	204	212	213	224	232	232	239
	SE	2	2	2	1	2	3	2	3	2	3	3	4	4	5	4	4	4	4	4
Group 1,2,3	Mean	93	106	115	123	132	144	151	159	170	177	183	191	202	206	209	218	227	229	229
	SE	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	3	2	3
Group 1,2	Mean	94	106	116	124	134	145	153	161	171	179	186	194	203	210	210	219	227	228	231
	SE	1	1	1	1	2	1	2	2	2	2	3	2	2	2	3	3	3	3	4

BODY MASS
FLIGHT ANIMALS
DURING FLIGHT AND POST-FLIGHT

	I.D.	FD1	FD2	FD3	FD4	FD5	FD6	FD7	FD8	FD9	FD10	FD11	FD12	FD13	FD14	R+0	R+1	R+2	R+3	R+4	R+5	R+6	R+7	R+8	R+9
Group1	14						316				353					346	344	335		334	336	337	330	327	330
	76						326				328					348	338	333		337	338	339	341	350	344
	13						290				298					313	306	302		304	307	314	312	321	320
	18						297				320					330	331	323		328	331	333	334	338	336
	24						305				330					347	333	324		331	325	333	322	343	342
Group 2	28						320				355					371									
	29						270				276					281									
	58						318				348					365									
	3						286				308					314									
	83						276				297					316									
Group 3	27						337				356					373									
	30						300				328					347									
	51						327				349					367									
	68						294				319					333									
	81						323				345					359									
Group 1							**307**				**326**					**337**	**330**	**323**		**327**	**327**	**331**	**328**	**336**	**334**
							7				**9**					**7**	**6**	**6**		**6**	**6**	**4**	**5**	**5**	**4**
Group 2							**294**				**317**					**339**									
							11				**15**					**16**									
Group 3							**316**				**340**					**356**									
							8				**7**					**7**									
Group 1,2,3							**294**				**317**					**329**									
							6				**6**					**6**									
Group 1,2							**300**				**321**					**333**									
							6				**8**					**9**									

Group 1	125-I Albumin and 59-Fe injection on FD6
Group 2	59-Fe and saline injection on FD9
Group 3	59-Fe and EPO injection on FD9

Saline dilutent - total volume injected 1.2 ml

BODY MASS (grams)

TRANSPORTATION CONTROLS For Growth Rate - PRE-FLIGHT

Shipped To And Housed At KSC During the Pre-flight Period and Flown From KSC to PRF on FD1

I.D.	L-24	L-23	L-22	L-21	L-20	L-19	L-18	L-17	L-16	L-15	L-14	L-13	L-12	L-11	L-10	L-9	L-8	L-7	L-6	L-5	L-4	L-3	L-2	L-1
37	98	107	118	127	134	144	151	159	165	175	181	191	194	200	202	210	217	218	225	233	245	251	227	263
41	100	108	117	126	133	138	149	151	158	163	170	179	185	189	193	202	209	211	219	224	237	247	253	259
44	96	106	116	124	134	142	151	159	170	177	186	191	202	207	208	221	227	229	239	244	258	265	276	279
46	94	108	125	121	131	137	145	153	158	168	176	182	188	194	198	206	215	216	226	233	247	257	268	269
48	97	106	118	126	139	150	159	167	178	190	197	205	212	219	227	238	246	253	263	274	287	295	305	317
49	95	103	116	125	131	142	151	157	169	176	183	191	198	202	210	220	221	227	239	245	258	268	274	282
87	87	104	113	123	131	139	149	152	160	166	175	183	191	196	193	203	207	209	217	221	234	242	250	255
91	99	108	116	122	137	144	151	160	167	174	179	185	194	197	199	210	216	217	230	233	243	250	261	265
94	97	108	115	122	131	142	152	158	169	175	183	190	198	207	206	215	222	224	238	243	257	266	274	279
98	96	109	118	126	137	145	155	163	173	180	193	194	204	212	210	220	225	230	238	241	253	261	271	276
Mean	96	107	117	124	134	142	151	158	167	174	182	189	197	202	205	215	221	223	233	239	252	260	266	275
SEM	1	1	1	1	1	1	1	2	2	2	3	2	3	3	3	3	3	4	4	5	5	5	6	6

Shipped To And Housed At PRF Throughout The Study

I.D.	L-24	L-23	L-22	L-21	L-20	L-19	L-18	L-17	L-16	L-15	L-14	L-13	L-12	L-11	L-10	L-9	L-8	L-7	L-6	L-5	L-4	L-3	L-2	L-1
101	100	114	126	134	143	150	154	169	176	183	188	196	203	210	221	226	231	242	252	256	267	279	283	297
102	85	101	111	121	125	135	144	151	159	167	175	184	189	195	205	212	217	226	233	239	247	257	261	271
103	94	109	120	129	138	148	158	166	175	182	190	199	205	213	223	228	236	244	251	258	264	282	281	291
104	95	108	118	127	135	146	153	162	170	178	188	189	205	212	222	230	235	248	255	257	268	283	283	298
105	102	116	128	138	152	159	172	180	188	200	206	216	222	232	244	249	260	273	278	285	294	308	310	322
106	93	109	120	129	136	148	154	163	172	179	185	193	200	207	219	226	233	246	253	257	267	278	283	294
107	92	109	118	127	137	145	154	161	168	174	183	189	195	205	212	222	227	238	245	251	259	273	274	285
108	88	105	114	123	132	143	151	159	164	174	180	192	196	204	213	218	225	234	240	245	250	264	267	278
109	86	105	114	124	131	140	151	159	168	176	182	194	198	207	218	227	236	243	251	258	265	275	282	293
110	97	111	122	131	141	150	160	165	174	183	189	200	204	214	224	232	242	248	258	264	272	283	287	294
111	87	105	116	126	138	147	156	167	174	183	190	202	208	213	228	236	246	254	262	266	276	287	291	303
112	90	111	119	128	139	147	156	165	174	183	190	200	207	216	227	236	243	253	260	268	278	287	293	303
113	91	108	119	128	138	146	155	168	172	181	188	197	203	211	223	231	240	248	257	260	270	286	286	297
114	85	103	115	124	133	143	151	159	172	177	185	194	142	206	220	225	233	243	248	255	264	277	283	298
115	93	111	120	133	139	151	161	170	180	189	197	208	212	222	234	242	250	260	268	277		299	302	315
Mean	92	108	119	128	137	146	155	164	172	180	188	197	199	211	222	228	237	247	254	260	267	281	284	296
SEM	1	1	1	1	2	1	2	2	2	2	2	2	5	2	2	2	3	3	3	3	3	3	3	3

BODY MASS (grams)

TRANSPORTATION CONTROLS For Growth Rate - DURING FLIGHT AND POST-FLIGHT

Flown From KSC To PRF On FD1 And Housed At PRF For Remainder Of The Study

I.D.	FD1	FD2	FD3	FD4	FD5	FD6	FD7	FD8	FD9	FD10	FD11	FD12	FD13	FD14	R+0	R+1	R+2	R+3	R+4	R+5	R+6	R+7	R+8	R+9
37	276	262	278	287	296	296	303	309	310	315	318	324	324	326	332	332	335	336	340	344	348	349	349	356
41	268	255	270	279	286	289	297	309	310	312	317	321	324	326	331	334	341	343	344	352	353	358	361	366
44	291	274	293	298	300	305	314	320	326	332	336	339	343	343	351	354	356	359	365	372	372	376	378	384
46	281	266	281	291	301	301	310	317	326	330	336	343	346	348	357	355	361	367	370	373	376	382	386	395
48	328	315	335	344	354	359	366	373	381	387	392	398	403	400	413	412	410	417	426	433	433	440	442	450
49	294	281	300	311	320	326	333	340	349	352	361	364	368	377	379	380	382	391	399	385	402	409	413	417
87	261	250	261	269	277	278	285	291	297	298	304	306	312	316	321	323	325	330	336	342	346	352	352	356
91	273	261	279	282	293	297	305	314	320	325	329	330	340	342	348	348	350	357	363	367	371	377	378	386
94	292	273	288	298	305	310	315	322	331	332	336	341	347	349	350	354	361	369	369	370	377	383	386	387
98	283	267	289	296	307	306	313	323	327	334	338	340	347	350	360	362	364	369	375	380	382	388	387	396
Mean	285	270	287	295	304	307	314	322	328	332	337	341	345	348	354	355	358	364	369	372	376	382	383	389
SEM	6	6	6	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	9	8	8	9	9	9

Shipped To And Housed At PRF Throughout The Study

I.D.	FD1	FD2	FD3	FD4	FD5	FD6	FD7	FD8	FD9	FD10	FD11	FD12	FD13	FD14	R+0	R+1	R+2	R+3	R+4	R+5	R+6	R+7	R+8	R+9
101	302	309	329	337	341	338	348	355	358	363	369	374	379	387	391	390	391	399	404	407	411	421	423	428
102	276	282	293	302	306	309	316	318	323	332	331	336	341	346	353	354	348	359	361	367	369	376	378	384
103	296	302	310	318	322	326	329	334	341	343	344	345	349	353	358	357	358	359	366	369	373	380	380	388
104	301	306	320	324	333	333	343	346	353	356	360	360	366	369	373	372	371	380	383	385	391	398	397	399
105	330	338	350	364	374	373	378	384	386	388	395	401	397	404	409	412	408	419	422	435	427	440	438	444
106	299	307	320	327	337	329	345	349	348	351	358	357	367	368	377	373	370	374	383	386	389	395	400	403
107	293	298	310	320	322	326	333	339	342	344	351	350	353	359	363	365	364	371	380	384	388	393	398	398
108	279	290	300	306	311	318	322	326	329	334	339	341	346	350	355	350	352	356	359	368	373	374	381	384
109	302	308	319	325	334	332	339	342	347	352	351	353	359	365	368	363	369	372	378	381	384	393	393	401
110	305	306	320	329	335	337	344	350	350	357	355	356	365	368	379	374	375	379	386	392	394	402	407	410
111	312	313	330	333	340	337	346	353	355	357	366	366	374	379	385	381	381	387	393	402	401	411	416	416
112	310	315	333	336	343	345	350	357	363	366	373	378	383	383	390	389	390	400	403	405	409	418	414	424
113	303	309	323	326	331	333	339	345	351	350	355	376	364	361	364	364	364	370	372	378	382	390	389	395
114	304	311	320	339	348	344	359	359	370	371	376	376	384	389	394	391	393	402	404	414	418	425	428	433
115	319	327	339	341	352	350	356	361	366	370	374	380	382	385	386	387	388	391	394	401	403	409	411	412
Mean	302	308	321	328	335	335	343	348	352	355	360	363	367	371	376	375	375	381	386	392	394	402	404	408
SEM	3	3	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	5	5	5	4	5	5	5

BODY MASS (grams)

TRANSPORTATION CONTROLS For Growth Rate - PRE-FLIGHT

Shipped To And Housed At KSC Throughout The Study

I.D.	L-24	L-23	L-22	L-21	L-20	L-19	L-18	L-17	L-16	L-15	L-14	L-13	L-12	L-11	L-10	L-9	L-8	L-7	L-6	L-5	L-4	L-3	L-2	L-1
32	98	108	118	124	135	144	150	162	173	179	187	194	204	209	213	224	229	232	244	250	262	271	277	279
34	91	106	116	124	134	140	153	165	172	184	191	204	207	219	214	226	233	234	243	252	268	272	285	286
39	98	109	122	131	138	151	161	167	175	186	194	201	208	215	216	225	231	236	245	247	262	275	279	287
43	95	106	113	122	129	139	147	154	161	168	176	185	191	196	198	203	208	209	218	223	237	241	248	250
45	96	109	118	124	137	145	154	162	168	178	183	191	193	205	205	215	220	220	232	236	247	255	264	270
50	101	110	122	129	141	154	164	169	179	188	195	203	209	215	217	224	231	234	241	245	261	270	279	282
89	98	116	119	133	140	151	160	167	178	183	195	201	212	215	218	227	234	242	242	249	264	272	279	287
92	93	106	112	124	137	148	155	165	174	184	192	199	200	214	217	229	236	240	247	256	269	277	288	294
95	100	112	117	125	136	148	156	165	174	180	188	196	201	210	212	219	227	233	240	245	254	263	270	277
Mean	97	109	117	126	136	147	156	164	173	181	189	197	203	211	212	221	228	231	239	245	258	266	274	279
SEM	1	1	1	1	1	2	2	1	2	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4

FLIGHT BACK-UPS (Shipped To and Housed At KSC Throughout The Study)

These Animals Had The Same Pre-flight Schedule for Injections and Blood Sampeles as the Flight and Groung Control Animals

I.D.	L-24	L-23	L-22	L-21	L-20	L-19	L-18	L-17	L-16	L-15	L-14	L-13	L-12	L-11	L-10	L-9	L-8	L-7	L-6	L-5	L-4	L-3	L-2	L-1
1	94	105	116	125	133	144	150	158	165	173	178	185	194	203	201	209	217	217	225					
5	92	100	109	117	126	136	146	148	158	166	172	182	185	197	198	206	216	212	225					
6	93	102	113	122	136	148	158	167	178	187	196	205	213	221	220	230	239	235	246					
12	99	111	119	129	139	151	161	168	177	186	194	202	207	217	218	228	237	234	244					
19	97	108	118	124	133	146	154	161	170	177	185	192	200	209	210	217	225	220	227					
23	96	110	121	128	137	151	159	166	175	186	193	201	210	217	219	230	236	232	235					
26	93	105	114	112	132	144	150	157	163	171	175	182	186	195	197	202	208	208	217					
55	94	106	120	126	140	151	159	163	175	184	187	194	198	203	208	212	221	219	229					
64	95	107	114	123	133	143	151	157	162	168	177	183	182	194	195	203	210	212	216					
67	99	113	117	126	137	146	153	160		174	183	190	198	206	204	214	221	224	231					
71	99	111	120	127	140	148	153	157	169	178	180	188	195	200	205	209	218	222	224					
75	91	101	112	121	129	139	147	155	161	169	173	183	191	196	202	211	216	218	224					
77	96	108	120	124	138	147	155	159	170	177	186	188	197	202	207	215	219	220	223					
80	94	104	114	122	131	143	150	160	170	178	185	195	201	207	208	216	223	225	227					
82	93	107	114	123	133	144	151	159	172	178	186	193	202	211	211	221	227	229	235					
Mean	95	107	116	123	135	145	153	160	169	177	183	191	197	205	207	215	222	222	229					
SEM	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2					

BODY MASS (grams)

TRANSPORTATION CONTROLS For Growth Rate - DURING FLIGHT AND POST-FLIGHT

Shipped To And Housed At KSC Throughout The Study

I.D.	FD1	FD2	FD3	FD4	FD5	FD6	FD7	FD8	FD9	FD10	FD11	FD12	FD13	FD14	R+0	R+1	R+2	R+3	R+4	R+5	R+6	R+7	R+8	R+9
32	289	297	299	308	318	322	325	333	337	338	349	352	356	357	365	367	372	374	378	379	382	382	382	382
34	298	302	311	301	322	328	336	341	347	353	358	365	364	377	379	366	388	390	401	406	411	414	419	422
39	304	305	308	317	325	332	339	345	348	354	359	359	362	372	373	378	386	385	392	392	398	402	398	401
43	262	265	270	276	277	283	286	295	296	300	301	308	315	321	322	324	333	329	335	338	340	345	345	346
45	283	285	294	299	307	310	317	324	328	334	340	343	350	356	357	365	369	371	377	379	385	384	389	390
50	295	301	310	317	319	326	335	336	345	342	354	357	361	361	361	369	370	376	377	379	378	383	379	381
89	295	300	308	314	326	330	337	344	348	353	360	365	368	373	374	383	389	393	402	401	406	406	405	408
92	303	311	318	327	335	345	350	354	366	375	377	385	389	395	398	406	410	413	420	419	424	426	425	434
95	286	288	297	308	312	316	320	328	333	336	342	348	353	357	361	366	371	375	380	381	384	388	384	386
Mean	291	295	302	307	316	321	327	333	339	343	349	354	358	363	366	369	376	378	385	386	390	392	392	394
SEM	4	5	5	5	6	6	6	6	6	7	7	7	7	7	7	7	7	8	8	8	8	8	8	9

FLIGHT BACK-UPS (Shipped To and Housed At KSC Throughout The Study)

After the Pre-flight Period Body Mass Was the Only Measurement Made On These Animals

I.D.	FD1	FD2	FD3	FD4	FD5	FD6	FD7	FD8	FD9	FD10	FD11	FD12	FD13	FD14	R+0	R+1	R+2	R+3	R+4	R+5	R+6	R+7	R+8	R+9
1		276	282	292	300	305	309	319	322	327	333	342	345	345	353	357	366	366	368	374	375	379	379	385
5		259	266	270	276	282	287	293	302	305	309	319	324	326	332	340	344	344	344	351	351	354	352	359
6		291	296	309	312	316	322	326	332	339	341	350	352	354	360	370	369	368	373	373	376	385	378	385
12		297	304	309	315	325	330	337	339	347	351	356	360	365	370	376	383	383	388	391	393	397	395	400
19		279	285	295	300	310	314	321	325	329	336	344	347	352	358	363	372	376	379	384	386	389	392	398
23		286	290	299	305	315	322	326	333	340	340	351	354	360	363	369	373	373	380	380	383	386	391	392
26		266	276	283	291	301	304	311	317	325	331	337	340	349	354	359	366	366	369	372	376	378	378	382
55		272	277	288	296	301	307	312	317	322	328	330	336	340	347	347	351	350	353	355	358	360	363	367
64		250	260	266	271	278	286	292	293	299	309	313	315	321	329	331	338	340	341	343	348	354	350	354
67		276	282	290	295	302	312	315	321	330	337	342	345	350	357	360	370	374	380	382	382	385	392	391
71		273	278	283	291	297	304	307	306	312	318	325	328	328	338	339	345	345	346	352	356	363	362	362
75		257	263	271	276	280	288	290	295	299	305	310	314	317	324	316	337	337	341	346	349	354	352	357
77		272	277	283	288	295	299	302	308	312	318	323	325	328	333	338	346	344	349	353	357	361	362	368
80		271	278	290	295	306	306	313	320	323	330	333	340	343	346	348	358	361	361	364	364	369	368	369
82		283	294	302	307	313	324	332	336	342	346	357	360	366	371	376	385	390	387	393	396	405	402	407
Mean		274	281	289	295	302	308	313	318	323	329	335	339	343	349	353	360	361	364	368	370	375	374	378
SEM		3	3	3	3	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4

Not part of Archive data

BODY MASS (grams)
PRE-FLIGHT

L+0 CONTROLS (KSC)

I.D.	L-24	L-23	L-22	L-21	L-20	L-19	L-18	L-17	L-16	L-15	L-14	L-13	L-12	L-11	L-10	L-9	L-8	L-7	L-6	L-5	L-4	L-3	L-2	L-1	L-0
31	91	101	114	126	136	143	155	159	172	154	184	194	203	209	213	221	230	231	253	249	262	270	283	288	301
33	97	111	120	126	136	152	175	166	152	179	182	195	203	218	214	227	234	236	249	257	270	282	290	296	306
38	95	104	117	125	134	138	146	151	160	168	174	181	186	193	196	202	210	208	222	223	236	246	255	260	273
85	89	105	113	116	127	133	141	150	155	160	171	177	185	191	191	198	206	207	222	227	239	247	257	263	275
86	89	105	116	122	133	140	144	150	159	168	170	180	187	191	187	197	202	201	211	212	221	227	234	235	243
90	92	106	115	125	136	147	158	164	175	184	190	202	206	191	185	213	227	229	246	247	264	269	280	287	291
93	98	111	121	129	143	150	158	166	182	185	194	204	219	220	224	237	244	248	262	267	274	305	294	303	311
96	99	104	115	125	136	145	155	161	171	181	191	197	207	218	214	221	229	233	244	246	256	263	269	274	282
97	91	103	108	115	126	137	140	146	155	162	170	177	186	191	192	199	205	205	215	218	227	234	237	241	252
99	92	107	113	121	137	146	155	166	172	181	193	202	209	216	216	227	234	236	245	248	266	273	280	292	301
Mean	**93**	**106**	**115**	**123**	**134**	**143**	**153**	**158**	**165**	**172**	**182**	**191**	**199**	**204**	**203**	**214**	**222**	**223**	**237**	**240**	**252**	**262**	**268**	**274**	**284**
SEM	**1**	**1**	**1**	**1**	**2**	**2**	**3**	**2**	**3**	**4**	**3**	**3**	**4**	**4**	**5**	**5**	**5**	**5**	**6**	**6**	**6**	**7**	**7**	**7**	**7**

MEAN BODY MASS (grams)

Group	L-24	L-23	L-22	L-21	L-20	L-19	L-18	L-17	L-16	L-15	L-14	L-13	L-12	L-11	L-10	L-9	L-8	L-7	L-6	L-5	L-4	L-3	L-2	L-1
A	95	104	115	123	134	143	152	158	167	173	181	190	198	205	207	216	222	222	229				257	
B	95	105	116	123	132	142	151	157	164	172	179	187	194	201	204	212	219	217	224				252	
C	93	106	115	123	132	144	151	159	170	177	183	191	202	206	209	218	227	229	229					
D	96	107	117	125	136	146	156	162	172	180	188	197	204	214	210	220	228	227	233					
E	96	107	117	124	134	142	151	158	167	174	182	189	197	202	205	215	221	223	233	239	252	260	266	275
F	92	108	119	128	137	146	155	164	172	180	188	197	199	211	222	228	237	247	254	260	267	281	284	296
G	97	109	117	126	136	147	156	164	173	181	189	197	203	211	212	221	228	231	239	245	258	266	274	279
H	95	107	116	123	135	145	153	160	169	177	183	191	197	205	207	215	222	222	229					

Group	FD1	FD2	FD3	FD4	FD5	FD6	FD7	FD8	FD9	FD10	FD11	FD12	FD13	FD14	R+0	R+1	R+2	R+3	R+4	R+5	R+6	R+7	R+8	R+9
A						294				317					329									
B						307				326					337	330	323		327	327	331	328	336	334
C						278				291					313									
D						281				291					309	316	315		320	325	335	335	347	339
E	285	270	287	295	304	307	314	322	328	332	337	341	345	348	354	355	358	364	369	372	376	382	383	389
F	302	308	321	328	335	335	343	348	352	355	360	363	367	371	376	375	375	381	386	392	394	402	404	408
G	291	295	302	307	316	321	327	333	339	343	349	354	358	363	366	369	376	378	385	386	390	392	392	394
H		274	281	289	295	302	308	313	318	323	329	335	339	343	349	353	360	361	364	368	370	375	374	378

A Flight Animals (N =15) Groups 1, 2 and 3

B Flight Animals (N = 5) Group1

C Ground Control Animals (N = 15) Groups 1, 2 and 3

D Ground Control Animals (N = 5) Group1

E Transportation Control Animals (N =10) Shipped to and Housed at KSC Pre-flight, Flown From KSC to PRF on FD1 and Housed at PRF for Remainder of the Study

F Transportation Control Animals (N =15) Shipped to and Housed at PRF Throughout the Study

G Transportation Control Animals (N =9) Shipped to and Housed at KSC Throughout the Study

H Flight Back-up Animals (N =15) Shipped to and Housed at KSC Throughout the Study

Same Pre-flight Schedule for Injections and Blood Samples as the Flight anbd Ground Control animals